Claims 1-21 have been canceled and replaced with new claims 22-42. Of these claims, claims 22-33 are directed to an "annular sliding fluoroplastics member," and claims 34-42 are directed to a "method of producing an annular sliding fluoroplastics member."

In view of the finality of the restriction requirement, claims 22-33 are subject to examination and claims 34-42 are withdrawn, since the scope of claims 22-42 is similar to that of claims 1-21.

Claims 22-33 are believed to patentably distinguish over the art of record.

The present invention as claimed in claims 22-33 relates in its broadest aspects as defined in claim 22, to an annular sliding fluoroplastics member with a composition including fluorine plastic and short fibers with a particular orientation of the short fibers, namely, 20 or more wt% oriented in a direction along which the magnitude of a load is large.

The present invention discloses a technique wherein the short fibers are oriented in the resin matrix thereby improving mechanical strength in a specified direction (i.e., the direction of fiber orientation) while maintaining matrix elasticity in the direction of fiber orientation.

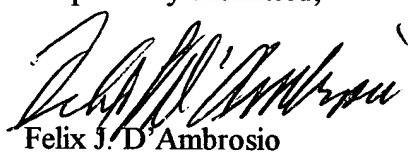
Because of the present invention, a bearing made of resin and which requires deformation characteristics, the characteristics of following the deformation are improved which can prevent separation between layers. Also, buckling-resistance and pressure-resistance are improved in the load direction, thereby also improving mechanical strength.

Braus discloses a technique wherein, in a composite material including fluororesin and short fibers, the matrix contains zinc sulfide or the like, thereby improving wear resistance of a friction contact or sliding layer of the composite material. There is no disclosure about short fiber orientation.

Hartel discloses an annular resilient body of fiber composite material for vibration-insulating support of a drive assembly, while windable long fibers (not short fibers) are wound around a body which includes a plurality of wound concentric layers formed of synthetic resin impregnated fibers. There is no disclosure of orienting short fibers. With Hartel layer separate is a real possibility because of the use of long fibers.

In view of the foregoing, reconsideration and re-examination are respectfully requested and claims 22-33 found allowable.

Respectfully submitted,



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Title of the Invention

ANNULAR SLIDING FLUOROPLASTICS MEMBER, AND METHOD OF PRODUCING AN ANNULAR SLIDING FLUOROPLASTICS MEMBER

Background of the Invention

1.Field of the Invention

The present invention relates to an annular sliding fluoroplastics member which is [requested] required to have good mechanical properties, resistance to abrasion and wear, thermal conductivity, hear resistance, and the like, and more particularly to an annular sliding fluoroplastics member which can be preferably used as a radial slide bearing, a thrust washer, or the like.

The present invention relates also to a method of producing an annular sliding fluoroplastics member which can produce such an annular sliding fluoroplastics member by means of simple steps.

2. Description of the Prior Art

As an annular sliding fluoroplastics member which is used as a radial slide bearing, a thrust slide bearing, a thrust washer, or the like, known are three types of annular sliding fluoroplastics members [of first, second and third prior art examples] which will be described below.

An annular sliding fluoroplastics member of [the] a first

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prior art example is molded by singly pressurizing and firing powder of granular fluoroplastics such as PTFE (Polytetrafluoroethylene) plastics.

An annular sliding fluoroplastics member of [the] a second prior art example is molded by pressurizing and firing a complex which is obtained by dry mixing short fibers such as chopped aramid fibers or powder of plastics with PTFE plastics.

An annular sliding fluoroplastics member of [the] a third prior art example is formed in the following manner. Short fibers made of fibrillated aramid plastics or the like, and PTFE plastics are uniformly wet mixed by, for example, a mixer. The wet mixed mixture is formed into sheet-like elements. [Plural] A plurality of such sheet-like elements are stacked to form a layered structure. The layered structure is fired and then subjected to various machining works such as a cutting work, to be formed into an annular shape.

The annular sliding fluoroplastics member of the first prior art example is excellent in resistance to abrasion and wear. In the member, however, [the] thermal conductivity is poor in the case where the fluoroplastics and the counter member directly slide over each other to generate [a] heat. Therefore, seizure easily occurs in the slide face, and hence it is difficult to [stably] maintain the sliding property stable for a long term.

In the annular sliding fluoroplastics member of the sec-

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ond prior art example, it [is] often happens that the short fibers are not uniformly mixed. In such a case, high-density portions of short fibers and low-density portions of short fibers [mixedly] exist in a mixture in the slide face. In a low-density portion of short fibers, the sliding area between the fluoroplastics and the counter member is increased so that, in the same manner as the annular sliding fluoroplastics member of the first prior art example, the thermal conductivity of the low-density portion of the short fibers is lowered. As a result, seizure easily occurs in the slide face, and hence it is difficult to stably maintain the sliding property for a long term. In a thrust slide bearing and a thrust washer, since a large press load is applied in the axial direction, it is preferable to orient the short fibers in the axial direction along which the [burden] magnitude of [a] the load is large, thereby enhancing the buckling resistance. By contrast, in a radial slide bearing, since a large press load is applied in a radial direction, it is preferable to orient the short fibers in a direction which is as close as possible to the radial direction so as to enhance the pressure resistance in a radial direction. In the annular sliding fluoroplastics member of the second prior art example, however, the short fibers are randomly oriented, and hence the buckling resistance, and the pressure resistance in a radial direction are so low that the annular sliding member has a low mechanical strength.

The annular sliding fluoroplastics member of the third

prior art example is produced by stacking plural sheet-like elements and cutting the resulting layered structure into an annular shape. Therefore, the production steps are complicated, and a large amount of chips must be disposed. As a result, the materials are wastefully used and the production cost is increased. Furthermore, most of the short fibers in the sheet-like elements are oriented substantially in one direction, and hence the orientation of the short fibers is restricted to a radial direction which is parallel to the radial direction, or is not always coincident with the direction along which the burden of a load is large.

Therefore, it is difficult to employ the method in which the orientation of the short fibers is restricted so as to improve the buckling resistance, and the pressure resistance in a radial direction, thereby enhancing [the] mechanical strength.

Summary of the Invention

It is an object of the present invention to provide an annular sliding fluoroplastics member in which, while maintaining [the] excellent resistance to abrasion and wear exerted by fluoroplastics, the mechanical strength[s] such as the buckling resistance and the pressure resistance in a large [burden of a] load can be enhanced by short fibers mixed with the fluoroplastics.

It is another object of the present invention to provide an annular sliding fluoroplastics member which has [a] good thermal

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conductivity so as to prevent seizure in a slide face between the member and a counter member from occurring, whereby the sliding property can be stably maintained of a long term.

It is a further object of the present invention to provide an annular fluoroplastics member which can omit a cutting work step from a production process, thereby preventing materials from being wastefully used, and reducing the production cost.

It is a still further object of the present invention to provide a method of producing such an annular sliding fluoroplastics member.

In order to attain the objects, the annular sliding fluoroplastics member of the present invention is characterized in that the member has a composite structure which mainly consists of flourine plastics and short fibers, and 20 or more wt.% of short fibers by weight of a total amount of the short fibers are oriented in a direction along which [a burden of a] the magnitude of the load is large.

According to the present invention, a large ratio of the short fibers are oriented in the direction along which [a burden of a] the magnitude of the load is large, so as to enhance the buckling resistance against a thrust load, and the pressure resistance in a radial direction against a radial load.

In the annular sliding fluoroplastics member of the present invention, when 20 or more wt.% of the short fibers by weight

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of the total amount of the short fibers may be oriented in an axial direction, a peripheral direction, or a spiral direction. Alternatively, 50 of more wt.% of the short fibers by weight of the total amount of the short fibers may be oriented in the direction along which [a burden of a] the magnitude of the load is large. As the short fibers, fibrillated aramid fibers may be used. As the fluorine plastics, PTFE plastics may be used. In the annular sliding fluoroplastics member of the present invention, preferably, the composite structure is a structure in which a number of flourine layers containing the short fibers 2 are stacked in a radial direction, and each of the stacked layers has a wavy sectional shape which undulates in a axial direction. In the case, preferably, overlapping faces of the layers are integrally coupled to one another.

In the annular sliding fluoroplastics member of the present invention, plural filaments may be stitched to the composite structure which mainly consists of the fluorine plastics and the short fibers. According to this configuration, [the] resistance to wear is improved and [the] mechanical strength is further enhanced by the reinforcing action of the filaments. As the filaments, preferably used are long fibers selected from aramid fibers, glass fibers, polyimide fibers, and PTFE fibers which are stretched, or metal wired selected from stainless wires, aluminum, and copper wires.

In the annular sliding fluoroplastics member of the present in-

vention, at least on surface of the annular sliding fluoroplastics member having the composite structure which mainly consists of the fluorine plastics and the short fibers may be covered with an expanded graphite sheet. In this structure, when the expanded graphite sheet is disposed in a slide face, the expanded graphite sheet slides over the counter member, and hence [the] heat resistance is improved by the properties characteristic [to] of an expanded graphite sheet. When the expanded graphite sheet is disposed in a face other that a slide face, such a that opposite toe the slide face, the sliding frictional heat generated int the slide face is radiated to a casing through the expanded graphite sheet, so that the sliding property is stably maintained for a long term.

In the annular sliding fluoroplastics member of the present invention, the annular sliding fluoroplastics member having the composite structure which mainly consists of the fluorine plastics and short fibers may be impregnated with lubricant. According to this configuration, the annular sliding member is provided with excellent resistance to abrasion and wear[s] by the lubricating function of the lubricant, thereby improving the sliding property. When the annular sliding member is used in a place where a sealing function is required, permeation of a fluid is prevented from occurring, thereby enhancing sealing property.

In this way, according to the annular sliding fluoroplas-

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tics member of the present invention, when the annular sliding member is to be used as a thrust slide bearing of a thrust washer in which a large press load is applied in the axial direction, 20 or more wt.% of short fibers are oriented in an axial direction along which [a burden of a] the magnitude of the load is large so as to enhance [the] buckling resistance against a thrust load, whereby [the] mechanical properties can be improved. When the annular sliding member is to be used as a radial slide bearing in which a large press load is applied in a radial direction, 20 or more wt.% of short fibers are oriented in a circumferential direction along which [a burden of a] the magnitude of the load is so large so as to enhance [the] pressure resistance in a radial direction against a radial load, whereby the mechanical properties can be improved. When 20 of more wt.% of short fibers ore oriented in a spiral direction corresponding to an intermediate of the axial direction and the circumferential direction, the annular sliding member can be used as a thrust slide bearing, a thrust washer, or a radial slide bearing which has both the buckling resistance and the pressure resistance in a radial direction. Since 20 or more wt.% of short fibers which are oriented in a direction along which [a burden of a] the magnitude of the load is large slide over the counter member, the resistance to abrasion and wear and [the] thermal conductivity are improved, so that the sliding property is stably maintained for a long tem. Moreover, a cutting work step can be omitted. Therefore, materials can be

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prevented from being wastefully used, and the production cost can be reduced.

The further detailed configuration and function of the annular sliding fluoroplastics member of the present invention will be more apparent from the following description of embodiments.

The method of producing an annular sliding fluoroplastics member of the present invention has the steps of: forming a mixture or fluorine plastics and short fibers into a sheet-like element; cutting out a tape-like element from the sheet-like element; spirally winding the cut out tape-like element to form an annular wound body; compressively deforming the wound body by pressurizing the wound body in an axial direction; during or after the deformation, heating the wound body to a temperature which is equal to or higher than a melt temperature of the fluorine plastics; and cooling the wound body to harden the wound body.

In the production method, a direction along which the tape-like element is cut out from the sheet-like element may be a direction which is perpendicular to the orientation of the short fibers, a direction which is parallel to the orientation of the short fibers, or a bias direction with respect to a rectangular sheet-like element. As the short fibers, fibrillated aramid fibers may be used. As the fluorine plastic[s], PTFE plastic[s] may be used.

In the production method of the present invention, plural fila-

ments may be stitched to the sheet-like element at intervals, and the tape-like element may be then cut out from the sheet-like element. In this case, as the filaments, preferably used are long fibers selected from aramid fibers, glass fibers, polyimide fibers, and PTFE fibers which are stretched, or metal wires are selected from stainless wires, aluminum wires, and copper wires.

In the production method of the present invention, when of after the tape-like element is spirally wound, an expanded graphite sheet may be placed over at least one surface of the annular wound body to cover the surface with the expanded graphite sheet. The annular sliding fluoroplastics member which has been cooled and hardened may be impregnated with lubricant.

The method of producing an annular sliding fluoroplastics member of the present invention will be more apparent from the following description of embodiments.

Brief Description of the Drawings

Fig. 1 is a perspective view showing a first embodiment of an annular sliding fluoroplastics member of the present invention;

Fig. 2 is a partially cutaway enlarged perspective view showing the annular sliding fluoroplastics member of Fig. 1;

Fig. 3 is a perspective view showing a sheet-like element;

Fig. 4 is a perspective view showing a state of cutting

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out a tape-like element;

Fig. 5 is a side view showing a step of winding the tape-like element;

Fig. 6 is a section view showing a step of pressurizing the wound tape-like element;

Fig. 7 is a diagrammatic plan view showing the orientation of short fibers of the wound tape-like element;

Fig. 8 is a perspective view showing an annular sliding fluoroplastics member having short fibers which are oriented in a direction adopted to a thrust slide bearing of a thrust washer;

Fig. 9 is a perspective view showing an annular sliding fluoroplastics member having short fibers which are oriented in a direction adopted to a radial slide bearing;

Fig. 10 is a perspective view showing an annular sliding fluoroplastics member having short fibers which are oriented so as to attain both [the] buckling resistance and [the] pressure resistance in a radial direction;

Fig. 11 is a partially cutaway enlarged perspective view showing a second embodiment of the annular sliding fluoroplastics member of the present invention.

Fig. 12 is a partially cutaway enlarged perspective view showing a third embodiment of the annular sliding fluoroplastics member of the present invention.

Fig. 13 is a partially cutaway enlarged perspective view

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showing a modification of the third embodiment of the annular sliding fluoroplastics member of the present invention; and

Fig. 14 is a partially cutaway enlarged perspective view showing a fourth embodiment of the annular sliding fluoroplastics member of the present invention.

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which has both [the] buckling resistance and [the] pressure resistance in a radial direction.

The ratio of the short fibers 2 which are oriented in the axial, circumferential, or spiral direction along which [a burden] the magnitude of [a] the load is large is requested to be 20 or more wt.% by weight of the total amount of the short fibers 2. When the ratio of the short fibers 2 which are oriented in the axial or circumferential direction is smaller than 20 wt.%, the ratio of random orientations is increased and the buckling resistance or the pressure resistance in a radial direction is reduced. In the case where a higher mechanical strength is [requested] required, it is preferable to set the orientation ratio of the short fibers 2 to be 50 or more wt.%.

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The annular sliding fluoroplastics member 10 to which the plural filaments 9 are stitched as shown in Fig. 11 can attain the effect that the resistance to wear is improved by the reinforcing action of the filaments 9, in addition to the effects of the first embodiment. Consequently, [the] mechanical strength is further enhanced.

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-Abstract of the Disclosure

The present invention relates to an annular sliding fluoroplastics member [(1)] which is requested to have good mechanical properties, resistance to abrasion and wear, thermal conductivity, heat resistance, and the like, and also to a method of producing such an annular sliding fluoroplastics member [(1)]. The annular sliding fluoroplastics member [(1)] of the invention has a composite structure which mainly consists of fluorine plastics and short fibers [(2)], and 20 or more wt.% of short fibers by weight of a total amount of the short fibers [(2)] are oriented in a direction along which a burden of a load is large. According to this configuration, the buckling resistance and the pressure resistance are enhanced. A member having a high buckling resistance can be used in a thrust slide bearing or a thrust washer in which a large press load is applied in the axial direction, and a member having a high pressure resistance can be used in a radial slide bearing in which a large press load is applied in a radial direction. In some cases, in the annular sliding fluoroplastics member [(1)] of the invention, filaments [(9)] consisting of long fibers may be stitched to the inner peripheral face or the like, the surface is covered with an expanded graphite sheet [(11, 13)], or the member is impregnated with a lubricant [(15)]. The member having such a structure is excellent in buckling resistance and pressure resistance in a radial direction, and also in